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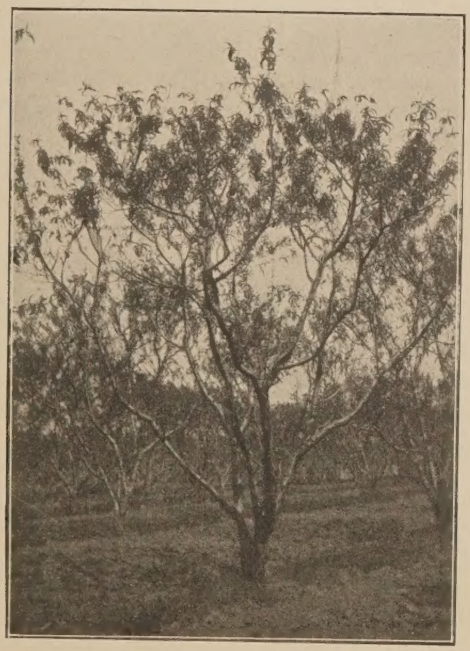
By RALPH E. SMITH.

Assisted by E. H. Smith, T. F. Hunt, and B. J. Jones.



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CALIFORNIA PEACH BLIGHT.

By RALPH E. SMITH.

Assisted by E. H. Smith, T. F. Hunt, and B. J. Jones.

The disease which forms the subject of this bulletin has come to be a well-known factor in peach-growing in practically every part of California where the fruit is extensively grown. While its general occurrence has been experienced only during the past few seasons, the disease has become so abundant and its effects so extremely disastrous that almost every peach-grower has come to know it and see the necessity of finding some immediate preventive treatment in order to save his trees from actual destruction.

The present publication aims to present the results of three years' experience and experimentation in the control of this trouble, showing the almost absolute success with which the disease has been controlled by treatment. The work has been unusually satisfactory in this respect, and it has apparently been fully demonstrated that by proper attention the grower can fully protect his trees and crop from the effects of the blight at a minimum expense.

Peach "blight' has been so frequently and fully discussed and described in our horticultural journals and meetings during the past two years that it seems scarcely necessary to consider in detail the nature and history of the disease at this time. So unusually sudden and pronounced have been the effects of the trouble in practically all the peach-growing sections, and so widely have methods of control been demonstrated and urged upon the growers by agents of the Experiment Station and others, that we have no plant disease in the State which is better known or for which control methods are more generally applied than this.

This disease appears to have been present in the State for some time. Professor Pierce records it as occurring previous to 1900,* and some growers recognize the trouble as one with which they have been familiar for a number of years. It was in the spring of 1904, however, that the "blight" began to attract much attention. The injured condition of many trees at that time was very evident. This was particularly the case in the Sacramento, San Joaquin, and Suisun valleys. A spotting, gumming, and death of the buds and twigs,

* Pierce, Newton B. Peach Leaf Curl. Bull. 20, Div. Veg. Phys. and Path., U. S. D. A., 1900, p. 179.

particularly on the lower part of the trees, appeared in some abundance at that time. The winter of 1905 was a very wet one, and the blight increased greatly that spring. By the middle of February, 1905, it was evident in many places that a fresh infection had taken place and the growers began very generally to see the necessity of finding means of controlling this new disease. Since another even more serious orchard disease, the pear blight, was making its first appearance

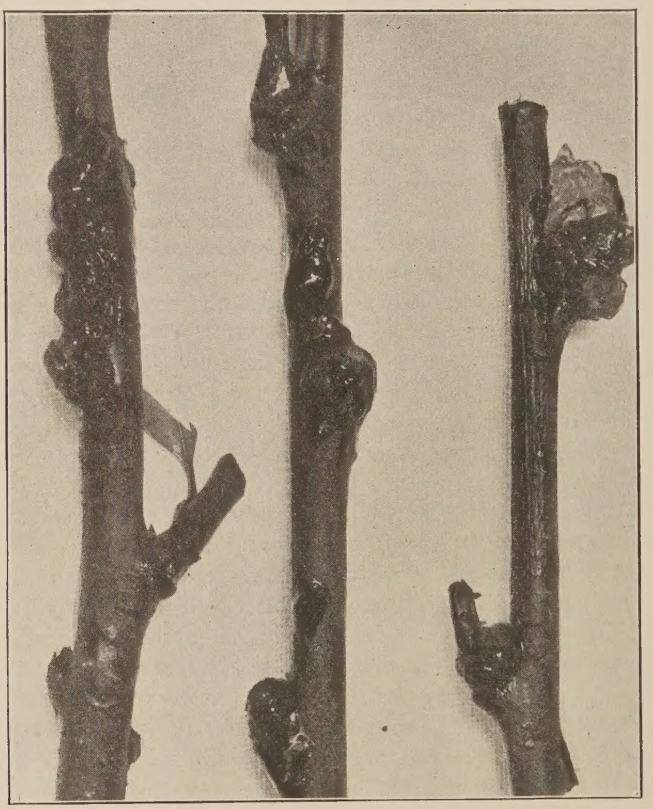

FIG. 1. Peach twigs affected by "blight."

in much of the same territory at the same time, the peach trouble was considerably overshadowed for the time. The writer first became familiar with the disease as a serious matter in the fall of 1904, since which time the matter has been under observation and experiment by the Station to a considerable extent, culminating in the general campaign of control in the fall of 1906. The blight was extremely prevalent in the spring of 1906, and somewhat less so, but still very destructive indeed in 1907. The large acreage of peaches which received

timely spraying previous to the latter season rendered the effects of the disease much less noticeable. In the unusually wet spring of 1905, it was noticed generally in the Sacramento, San Joaquin, and other valleys that peach trees were affected to an alarming extent with some unusual condition. The trouble consisted in the dying of

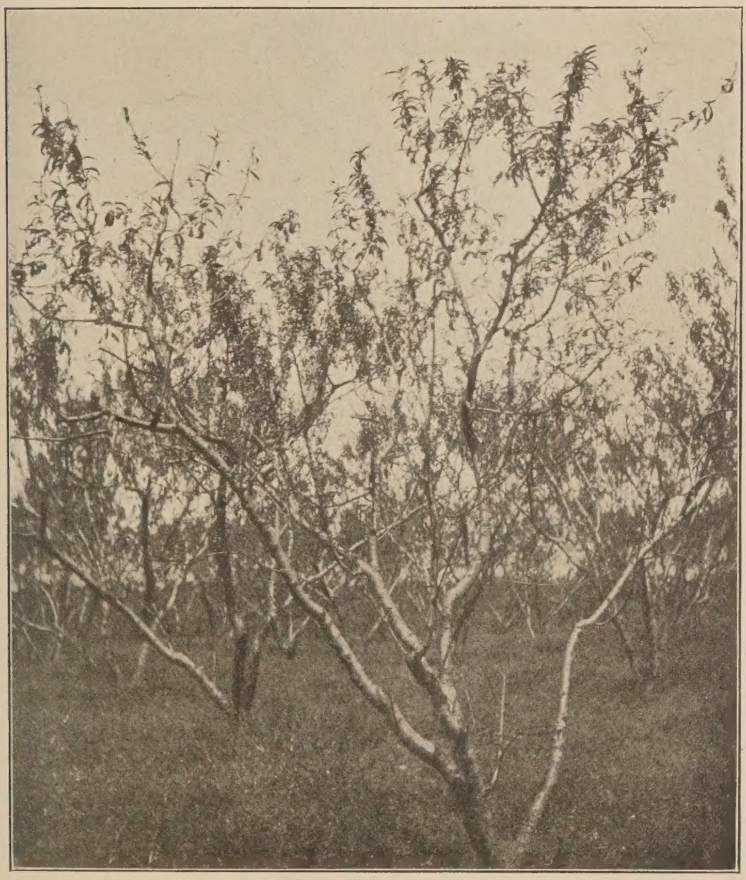

FIG. 2. Peach orchard, showing typical blight effect.

the buds on the fruiting wood, spotting of the green twigs, and dropping or non-development of the young leaves and fruit. Particularly noticeable, and the most prominent feature of the disease, was a copious "gumming," or exudation of masses of gelatinous sap from the twigs, originating in the dead spots and buds. This gumming was extremely abundant in wet weather all over the one-year-old fruiting twigs of affected trees, and with the blighted leaves and fruit and

spotted, leafless, dead or dying twigs and shoots, gave the tree a most distressing and alarming appearance. The crop was entirely ruined in badly affected orchards and the trees brought into an extremely weakened condition. (Figs. 1 and 2.)

This describes, in a general way, the nature of this disease. It is readily distinguished from any other peach trouble by the features mentioned. It is essentially a winter or early spring disease of the fruiting twigs, the one-year-old wood which is the valuable part of the

FIG. 3. Effect of blight on fruit of peach.

tree. This growth becomes killed all through the tree, except in the very top, and very serious loss and injury result. Most of the infection takes place in the winter, before the new growth starts, on twigs which were healthy and free from the trouble at the end of the growing season the previous fall. The new fruit becomes affected to some extent, as shown in Fig. 3, but the principal damage is done by the killing of the buds and whole twigs at a period previous to the development of fruit.

During 1905 and 1906 the disease occurred in greater abundance, appearing in all the peach-growing sections. Santa Clara County and the southern California peach sections were the last affected, but the

blight now occurs in both regions. The losses occasioned by the "blight" have been enormous, particularly in the seasons above mentioned when

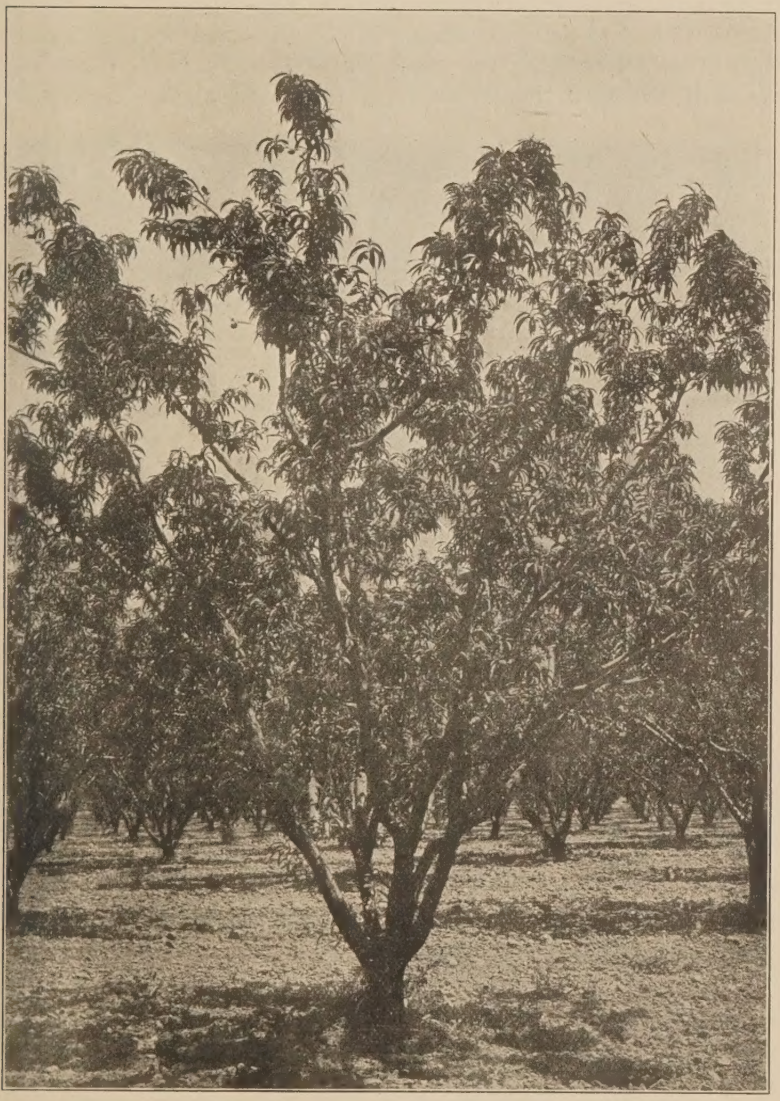

FIG. 4. Peach tree sprayed in December, 1905. Photo taken in May, 1906. Compare with Fig. 2.

climatic conditions were particularly favorable and little was done to check the disease. Indeed, it may truthfully be said that in the summer of 1906, after two years of active prevalence of the "blight," the

peach orchards of the Sacramento and San Joaquin valleys, the main commercial acreage of the State, would have been in an absolutely ruined and unproductive condition without some means of checking the disease. The trouble was abundant in every orchard, all varieties were more or less affected, and the younger growth, which in the peach bears the fruit, had been almost completely killed and further development

FIG. 5. Effects of blight.

prevented. With the disease unchecked peach-growing was apparently at an end.

THE CONTROL OF THE BLIGHT.

Most fortunately, under these serious conditions, there has been evidence almost from the first that the disease could be successfully controlled. When, in 1904 and 1905, the blight began to be abundant enough to attract notice, it was evident to all who observed the matter closely that the usual practice of peach spraying in February or March was *too late* to check infection by this disease. Twigs which were sound and healthy in December were found to be spotted with infection by the first of February. Even with the heaviest and most

thorough spraying with Bordeaux mixture, or lime, salt and sulfur, applied at the usual time, the gumming produced by the blight would be found breaking out directly through the spray coating on affected twigs, and the disease was not checked in the least by the application. Knowing the cause of the disease to be a parasitic fungus, and with this habit of midwinter infection and development suggested by the

FIG. 6. Results of December spraying. Compare with Fig. 5.

experience of 1904 and 1905, the idea became quite general by the fall of 1905 that spraying in December would be the most promising time for successful control. The disease being new, and the fall season of 1905 an exceptionally dry one, the majority of the growers held to the hope that the blight would not occur again as before and took no unusual means for its control. Several in the Suisun Valley, however, and a few in the San Joaquin and elsewhere, sprayed their trees in December, and when the very severe development of the disease came on in February, 1906, the results were most complete and striking, showing in general that one thorough spraying early in December with the Bordeaux mixture absolutely prevented the disease. (Fig. 4.)

After December results were not so good, and gradually deteriorated up to February, from which time on sprayed trees were no better than

FIG. 7. Effects of blight on fruiting twigs, 1906.

unsprayed in respect to this disease. One orchard, sprayed mostly in December, but finished out late in January, showed a decided difference in the two portions. Spraying in December was perfectly suc-

cessful; in January partially so, and in February and March without effect on this disease. The blight was so bad in unsprayed or late-

FIG. 8. Twigs from December-sprayed tree, 1906.

sprayed orchards, with the crop and foliage almost entirely gone, and all the growth on those sprayed in December perfect, particularly the lower, inner, blight-susceptible fruiting twigs, that one seldom sees

so striking a contrast in the treatment of any plant disease. Abundant comparison was available between trees of the same variety, age, and condition. (Figs. 5 and 6.)

Effect on Curl Leaf Equally Good.—The writer took some pains to note in this connection the effect of this early spraying on curl leaf, inasmuch as any peach treatment must take this disease into consideration. (Fig. 7.) So far as could be judged, the effects were equally good, and the disease controlled as well as by the usual later spraying. The fine condition of a block of December-sprayed Susquehannas was especially noticed, while unsprayed trees on this and even less curl-susceptible varieties were badly affected by curl leaf wherever the blight fungus had left any leaves on the tree. (Fig. 8.)

To summarize: Unsprayed trees were very badly affected by blight and curl leaf.

Trees sprayed in December were free from any disease.

Trees sprayed late in January were somewhat affected by blight, but free from curl leaf.

Trees sprayed in February and early March were free from curl, but no better than the unsprayed in regard to blight.

In the light of these results and in view of the serious and demoralized condition of the peach industry in the spring of 1906, a thorough campaign of peach-spraying and experimentation was planned by the Station for the season of 1906-07. So bad was the condition of practically every orchard that it was not deemed sufficient to simply carry out a few limited demonstrations and experiments. In order to meet the situation adequately it was necessary that practically every grower in the principal sections be personally visited and instructed in the best method of procedure, in order that no further time be lost. In accordance with this plan assignments were made to Messrs. Jones and Hunt to the Sacramento and San Joaquin valleys, respectively, to urge the growers to spray in November and December, to instruct and assist the inexperienced in proper methods of work, and to follow up the work done and the results accomplished. Series of experiments were also carried out, in spraying at different seasons, for blight control. In addition to the Station efforts, great good was accomplished by the Boards of Horticulture in many of the counties along the same line. Early spraying was urged upon the growers at every opportunity by these men in the valley counties and elsewhere, and many a 1907 crop is the result of their efforts. The State Commissioner of Horticulture was also active in spreading the propaganda.

As a result of this effort and the very serious condition of the peach orchards, spraying in November and December, 1906, was almost uni-

versal in the San Joaquin and Sacramento valleys. Such a concerted and general effort has rarely been made in the attempt to control any plant disease. From October to March the Experiment Station representatives were constantly in the field in the upper San Joaquin and lower Sacramento, our greatest peach sections. The recommendation made was to spray between November 15 and December 15, with Bordeaux mixture of the strength 30-35-200 (bluestone, lime, water). The work was entirely new to many of the growers, particularly in the San Joaquin Valley, where there had been little cause for spraying peaches hitherto, and much time was spent in instructing the inexperienced in making the mixture and applying it to the trees. The fact that four hundred spray pumps were sold at one small town, as recorded by a horticultural paper, indicates both the extent of the operations and the fact that it was new to most of the growers. Naturally, under these circumstances, many mistakes were made and much poor spraying resulted. Another season will certainly find the growers much better prepared to spray their trees properly. Weather conditions also were most unfavorable to spraying at the desired time, on account of continuous rain. The condition of the trees resulting from previous attacks of the disease was also to be considered. To one familiar with the state of a large part of our peach orchards in the spring of 1906 it would seem little short of miraculous to have anything like a full crop in 1907 on the same trees, and in fact even less surprising if the trees had all died. With all the lower twig growth killed, most of the leaves fallen in early summer, the crop almost entirely on the ground, no wood developing for a new crop, and the whole life of the tree confined to a few straggling twigs in the top, the outlook at the end of last season was indeed discouraging.

Still further trouble was caused by a shortage of bluestone, many being totally unable to procure the material, and, if at all, only at an exorbitant price. All in all, therefore, the results of the past season may be taken as a very conservative basis for future calculations.

The time suggested for spraying was chosen, as already shown, on the basis of the limited experience of the previous season and the known fact of the time of infection. After following the matter carefully for several seasons it has appeared that each year about the first week in January the signs of the disease make their appearance. At this time the indications of the blight of the previous year are very abundant everywhere in the shape of dead, cankered spots on the growth of the preceding year. From these spots copious gumming begins with the winter rains. Up through December, however, the new growth of the season, the young twigs which bear the fruit buds, are green and vigorous, save for a very few occasional blight spots which may have formed early in the preceding summer. The buds are alive and vigor-

ous, and on what bearing wood there is the indications are in no way other than for a good crop. In the case of very heavy rains previous to the first of January there may be considerable infection even before that date, as occurred in December to some extent during the past season, but the main infection appears to come on quite uniformly at about the time of the new year. From this time on through the winter further infection is abundant and rapid, occurring in proportion to and along with the rainfall. Up to December 15th almost every twig is green, sound, and unaffected. With abundant rain before or about that time the brown, or at first reddish, dead spots begin to appear, especially at the base of the buds just where they join the twig. (Fig. 7.) In this way the buds are killed and the crop as well as the growth for the next year is destroyed. This has not, in our observations, become abundant until January 1st, about which time the infection occurs very rapidly. In this way twigs which were entirely sound late in December may have almost all their buds and the twig itself killed, spotted, and gumming six weeks later.

FIG. 9. Unsprayed trees, 1907.

The results of spraying in the fall of 1906 became very apparent by February 1st. Trees well sprayed before the infection started had the twigs and buds still alive and sound, while unsprayed trees were show-

ing very bad infection and gumming. In one case the writer saw an orchard on January 8th which was just then being sprayed, and in which the work was stopped before completion, on account of rain. On the last rows sprayed, as well as on those unsprayed, the blight spots were appearing in great abundance on the twigs, breaking out directly through the spray in numerous cases, and it was most evident that so far as blight was concerned the best time for treatment had passed, though spraying might still prevent further infection, which might result from more rain.

A very important complication must be considered in spraying for blight control; this is the occurrence of another peach disease, the Curl Leaf. The effects of this trouble are too well known in California to need description. The control of the disease is very successfully accomplished by spraying in February or March, just before the buds unfold, but a time which, as has already been shown, is too late for blight prevention. In the experience of 1905 the one fall spraying controlled both diseases—a most satisfactory condition. In the spring of 1907, however, a very virulent attack of curl leaf occurred, especially in the lower Sacramento Valley, while the blight fungus proved somewhat less active than in the previous season. The result of this is plainly shown by the results of spraying,

FIG. 10. Tree sprayed in November, 1906, and February, 1907.

viz: that the November or December application did not entirely hold the curl leaf in check, although as successful as before with the blight. Consequently some orchards sprayed properly and successfully for blight were badly injured by curl leaf, while others sprayed later were protected from curl leaf and left in better condition at the end of the season than those in which the blight alone was controlled. All that had been expected of the blight treatment held good when its effects were differentiated from those of the other disease, but the necessity of *two sprayings rather than one for the positive control of both diseases* has become evident.

FIG. 11. Left side of tree sprayed in December, 1906, right side unsprayed.

The following table gives in condensed form the record of a number of typical orchards in the regions where our work was centered. The column of formulas expresses the amount of bluestone, lime, and water used in each instance. The names of varieties are abbreviated as follows: C, Crawford; Cl, Crawford Late; E, Elberta; F, Foster; G, Georgia; Ha, Hale; H, Henrietta; I, Imperial; L, Lovell; Mc, McDevitt; Ma, Mary's Choice; Mu, Muir; O, Orange; P, Phillips; Sa, Salway; Su, Susquehanna; T, Tuscan; W, Wheatland.

In orchard No. 1, for instance, Muirs, Lovells, and Elbertas were sprayed December 22d and in February, each time with Bordeaux

mixture made with 30 pounds of bluestone, 30 pounds of lime, and 200 gallons of water.

The acreage represented in this table is about 2,500. The orchards sprayed in the fall of 1906 for blight control, as a result of the efforts

FIG. 12. Twigs from sprayed and unsprayed trees, 1907.

of the Experiment Station and others, amounted certainly to ten times this amount, or 25,000 acres at a very conservative estimate, as there are at least 50,000 acres of bearing peaches in the area under observation and an unsprayed orchard was very much the exception. The data given in the table are representative of average conditions, taking

the orchards as they come, from which it appears that most of the orchards were sprayed, and a very large majority at the proper time and with good results.

Cases like Nos. 89 and 124 show the loss of practically the whole crop where no spraying was done, and Figs. 9, 10, 11 and 12 indicate plainly the comparative results of proper spraying and no treatment. Fig. 11 is particularly suggestive, showing on the same tree a heavy crop and full foliage on one side, which was sprayed, and the complete blighting and ruining of the crop on the other side, which received no treatment. In view of these results a saving of $20 per acre is certainly a moderate estimate, which on the acreage stated would amount to a gain of $500,000 in the season's crop, not considering the saving of the trees and possibilities of even better results in the future. As a matter of fact the saving effected might reasonably be estimated as the difference between no crop at all and a large and profitable one, as well as the saving of the trees themselves, in which case the figures would rise very much higher. As the whole expense to the State and counties for this saving was probably not over $1,500, the practical value of this work is quite apparent.

RECORD OF TYPICAL PEACH SPRAYING, 1906-07.

No.	Locality.	Varieties.	Bordeaux Formula.	Dates.	Results and Remarks.
1	Hanford	Mu, L, E	30-30-200	Dec. 22, '06 Feb. '07	Trees in fine shape. Big crop. No blight.
2	"	Mu	30-35-200	Dec. 5, '06	Big crop. No blight.
3	"	Mu, E, T, P, H, Mc	24-40-200	Nov. 15, '06	Little or no blight. Fine crop.
4	"	Mu, L, Su, Sa, P, O	30-36-200	Dec. 26, '06	Little blight on old trees. Some curl leaf. Fine crop.
5	"	Mu, E	30-40-200	Dec. 5-30, '06	Old trees; considerable blight. Poor spraying in part.
6	"	Young trees	30-35-200	Dec. '06	Trees in fine condition. No blight.
7	"	F, Mu, L, E, O	30-35-200 20-20-200	Dec. 8-30, '06 Feb. '07	Very little blight. Good crop. Trees look fine.
9	"	E, P, W, Mu	30-30-200	Dec. 1-20, '06 Feb. '07	Good crop. Very little blight.
10	"	Mu, C, S	30-35-200 20-25-200	Dec. 7, '06 Jan. 2, '07	Poor job first spraying; second good. Big crop. Trees fine.
11	"	Mu, E, P	30-40-200	Dec. 1-30, '06	Very little blight. Trees look well.
12	"	Mu	32-32-200	Dec. 12-22, '06	No blight. Trees fine.
13	"	Mu, E, T, L	40-48-200	Nov. 29-Dec. 10, '06	Young trees. No blight.
14	"	Mu, E	16-20-200	Dec. 8-15, '06 Feb. '07	No blight.
15	"	Mu, E, Cl, Sa	32-36-200	Dec. 15-18, '06	Little blight in very old trees; others good.
16	"	Mu, Cl, Su, E	30-35-200	Nov. 20, '06 Jan. 5, '07	Poor work at first, but repeated. No blight. Best crop ever had.
17	"	Very old trees	30-35-200 20-20-200	Dec. '06 Feb. '07	Trees fine. Very little blight. Heavy crop. Very bad in 1905-6.

RECORD OF TYPICAL PEACH SPRAYING, 1906-07—Continued.

No.	Locality.	Varieties.	Bordeaux Formula.	Dates.	Results and Remarks.
32	Dinuba	Mu, L.	40-48-200	Dec. 17, '06	Poor spraying. Trees and crop poor. Some blight; much curl leaf.
33	"	Mu, E, I, P, O	40-48-200	Dec. 13, '06	Elbertas curled badly. Very poor spraying. Some blight.
34	"	Various	24-24-200	Dec. 8, '06	Very little blight. Good crop.
35	"	Mu, C, E	25-25-200	Feb. 22, '07 Dec. 19-30, '06	Little blight. Some curl on Elbertas.
36	"	Mu, L, P	36-36-200	Dec. 24, '06 Feb. 15, '07	Little or no blight. Good crop.
37	"	Mu, L	36-36-200	Dec. 12, '06 Feb. 15, '07	No blight. Good crop.
38	"	Mu, L, P, O, T, E, W	28-32-200	Dec. 1, '06 Feb. 15, '07	No blight. Good crop.
45	Armona	Mu, E, L	28-40-200	Dec. 22, '06	No blight.
46	"	Mu, E, L	28-40-200	Dec. 29, '06	No blight. A little curl leaf.
47	"	Su, Sa, Cl	28-40-200	Dec. 20, '06	Little or no blight.
48	"	Mu, L, E	30-44-200	Dec. 29, '06	No blight.
49	"	Mu, E, C, O, Su	24-28-200	Dec. 5-24, '06	A little blight and much curl leaf.
50	"	Mu, C, O, Sa, Su, Cl	24-40-200	Dec. 10-19, '06	No blight.
56	Kingsburg	O, Mu, Sa, F, Su	40-48-200	Dec. 16, '06	No blight. Big crop. A few trees not sprayed have no crop and bad blight.
57	"	Mu, O, T, C, Su	48-48-200	Dec. 15, '06	Very little blight Good crop.
58	"	Mu, O, P	36-40-200	Nov. 20, '06	No blight. Heavy crop.
59	"	T, P, O, Mu, L, Su	36-40-200	Dec. 12, '06	No blight. Fine crop.
60	"	Mu, O, E, F.	40-48-200	Dec. 15, '06	No blight. Fine crop.
61	"	C, L, O	36-40-200	Dec. 18, '06	Did poor job. Much blight. Very light crop.
72	Del Rey	Mu, C, O, Sa, Su, P	30-35-200 20-20-200	Dec. 17, '06 Feb. 15, '07	Very little blight. Fine crop.
73	Visalia	P	40-48 200	Dec. 1, '06	One row poorly sprayed, badly blighted. On the rest no blight.
74	"	P, O	40-48-200	Nov. 27, '06	Trees badly injured by standing water.
75	"	Ma, Mu, O, E, C, Sa, P	48-48-200	Dec. 12, '06	Very poor work. Much blight.
84	Selma	Mu, Su, O	40-48-200	Sept. 1, '06 Jan. '07	Poor spraying. Considerable blight and light crop.
85	"	P, O, Mc	32-42-200 20-20-200	Dec. 14, '06 Feb. '07	No blight; a little curl leaf. Fine crop.
86	"	Mu, C, O	30-35-200	Dec. 20, '06	Poor job. Much blight. Fair crop.
89	Sultana	Unknown	Not sprayed		Trees badly blighted. Very little fruit.
109	Yuba City	T, Mc, O, F, Mu,	20-20-200	Sept. 25, '06	Badly affected with blight and curl leaf.
109 A	"	"	24-24-200	Sept. 25, '06	Showed some advantage over last in blight, but bad with curl leaf.
109 B	"	"	20-20-200	Sept. 25, '06 Feb. 13, '07	Much better than last, especially in regard to curl leaf.
109 C	"	"	20-20-200	Oct. 24, '06	Little blight, but bad with curl leaf.
109 D	"	"	30-35-200	Oct. 24, '06	Somewhat better than last regarding blight.

RECORD OF TYPICAL PEACH SPRAYING, 1906-07—Continued.

No.	Locality.	Varieties.	Bordeaux Formula.	Dates.	Results and Remarks.
109 E	Yuba City	T, Mc, O, F, Mu	20-20-200	Feb. 13, '07	Considerable blight. Good control of curl leaf.
110	"	T, Mc	30-35-200	Dec. 1, '06	Very free from blight; considerable curl leaf.
110 A	"	P, Mc	30-35-200	Jan. '07	More blight than last. Less fruit. Less curl.
110 B	"	P, Mc	30-35-200	Feb. '07	Very bad with blight. Free from curl.
111	"	Unknown	30-35-200	Feb. 15, '07	Blight very bad. Good control of curl leaf.
112	"	Mu, I, Ha	30-35-200	Nov. 27 to Dec. 20, '06 Mar. 6, '07	Very little blight, or curl leaf.
112 A	"	C	30-35-200	Nov. 20, '06	Even less blight infection than last.
113	"	T, Mc, O, W, Mu	30-35-200	Nov. 20, '06	Very little blight; considerable curl leaf.
113 A	"	C	30-35-200	Nov. 20, '06 Mar. 1, '07	Free from blight and curl leaf.
114	"	Unknown	30-35-200	Mar. 13, '07	Blight very bad; very little curl leaf.
114 A	"	Unknown	Not sprayed		Blight and curl leaf very bad.
115	"	Mu, O, T	36-40-200	Feb. 10, '07	Some blight, but fairly good.
115 A	"	P	36-40-200	Jan. 18, '07	Quite bad with blight and curl leaf.
115 B	"	P	36-40-200	Jan. 18, '07 Feb. 10, '07	Less curl leaf than last.
116	"	C, Su, G		Nov. '06 Feb. 10, '07	Fine condition. No blight or curl leaf.
117	"	Apricot	60-72-200	Nov. 7, '06	Crop spoiled by rain, but full bloom and foliage.
118	"	Unknown	36-36-200	Dec. 7, '06	No blight.
119	"	Unknown	30-35-200	Feb. 5, '07	Blight very bad.
120	"	Unknown	36-36-200	Feb. '07	Blight very bad.
121	"	Unknown	30-35-200	Nov. 10, '06	Very little blight.
122	"	Unknown	Unknown	Nov. '06	Very little blight.
122 A	"	Unknown	Unknown	Feb. '07	Part of same orchard as last. Blight much worse.
123	Marysville	Various	Rex	Feb. '07	Twigs already infected. Blight abundant.
124	Chico	F	Unsprayed		Blight and curl very bad. No crop.
124 A	"	Mu	Unsprayed		Blight less than last. Curl very bad. Light crop.
125	"	Bidwell	Unsprayed		Blight and curl very bad.
142	"	Various	Unknown	Nov. '06, to Mar. '07.	Excellent blight and curl leaf control by fall and spring spray.
126	Red Bluff	Mu, C, Ma, Cl	30-35-200	Jan. 10, '07	Considerable previous blight infection. Checked by spray.
127	Oakdale	Cling	40-60-200	Dec. 7, '06	No blight.
127 A	"	Cling	40-60-200	Dec. 14, '06	Part of same orchard as last. Rain Dec. 10. Some infection on these.

The records in this table represent sprayings with various strengths of Bordeaux mixture, in a number of sections of the Sacramento and San Joaquin valleys, at times ranging from September to March, and

on all the usual varieties of peach. A study of this table gives a clear idea as to the most successful manner of treatment.

Time of Spraying for Blight Control.—September was too early and February and March too late. Spraying in the latter part of October seemed effective, and from then on to the middle or last of December the best results of one application were secured in preventing blight infection.

The attacks of curl leaf complicated matters. In many cases a complete blight control, obtained by early spraying, was nullified by unchecked attacks of the other disease. Spraying in November and December did not altogether hold the curl in check, while the February and March applications did so perfectly. It therefore seems best in the future to advise *two sprayings, one early and one late*, to insure freedom from both diseases.

As a third peach pest, the Peach Worm may be controlled by spraying with lime, salt, and sulfur just before the buds open, a treatment that is equally efficacious for curl leaf, we suggest this for the second spraying rather than Bordeaux mixture.*

Kind of Mixture.—Practically all these results refer to Bordeaux mixture. We have reason to feel sure that lime, salt, and sulfur spray would give equally as good results, but for the blight alone the more easily prepared Bordeaux is usually preferable.

Proportion of Mixture.—We have not laid great stress on the exact formula for the Bordeaux mixture to be used. Where the mixture was properly prepared very little difference in the results has appeared, whether it was 20-20-200, 30-35-200, or very much stronger as some have used it. Ordinarily the 20-20-200 formula is probably strong enough and affords some saving of material over a heavier application. A mixture containing more copper and lime remains longer on the tree, however, is not as quickly washed off by rain, and shows more plainly on the tree just how thoroughly it has been covered. We would therefore advise the use of the lesser strength only when materials are very high and scarce or where the workmen are particularly adept in applying the spray perfectly. For average conditions we prefer the 30-35-200 for the early application.

Preparing the Mixture.—The preparation of Bordeaux mixture has been described almost too frequently to need repetition. The lime should be of the best and perfectly unslaked, and slaked in a considerable amount of the water and stirred and strained to make a perfectly smooth whitewash. The bluestone is to be dissolved in water, a stock

* See Bulletin No. 144, California Experiment Station.

solution of known strength being most convenient. In mixing the two, plenty of water should be used to keep them well diluted, and the mixture well churned together, strained, and diluted with the remainder of the water.

Relation of Spraying and Pruning.—The early time of spraying recommended for blight control is apt to find the trees unpruned and with considerable foliage still on the branches. This at first seemed a serious obstacle to some, but experience has shown that even in this condition the trees may be sprayed with perfect success, provided a thorough job is done. It is very desirable to have the trees pruned before spraying, and this should be done if possible, but spraying should on no account be delayed beyond the proper time because the trees are not pruned. If the pruning can not be done in time the spraying should proceed very thoroughly, and the pruning done later.

Application of the Spray.—Instances like Nos. 32, 33, 61, and 73, of the table, show the results of poor spraying. Many growers went over their trees a second time, on being shown their mistakes. The effort should be made, above all, *to cover all the branches and fruiting twigs completely with the spray.* The inexperienced workman soaks the trunk and main limbs, but leaves untouched much of the small growth which bears the fruit and which the blight particularly affects. In order to check the blight infection on the twigs, those twigs must be completely covered with spray before infection occurs. The least portion of a twig left uncovered is as exposed to infection as though there was no spray on the tree at all. An experienced and conscientious sprayer goes over his tree systematically and completely, leaving no portion uncovered and yet wasting no material.

Relation of Peach Varieties to Infection.—We have been able to find no fixed rule as to the relation of the different peach varieties to the blight. In some sections or seasons one kind has been much the worst, while in another quite a different condition held good. No variety has been at all immune to the trouble, but all quite badly affected.

THE PEACH BLIGHT FUNGUS.

The fungus causing the so-called "blight," or "shothole fungus," has been identified by us as *Coryneum beyerinkii* Oud. This has been mentioned frequently as doing damage in this country, though never to nearly so great an extent as in California. Trabut reports the same fungus as occurring extensively in Algeria in 1904, on apricots, peaches, and cherries.[4]

McAlpine,[3] in discussing the shothole fungi of the stone fruit, describes the fungus *Clasterosporium carpophilum* (Lev.) Aderh., which he considers identical with *Coryneum beyerinkii*. Our fungus appears to be correctly classified as *Coryneum*, in that the spores are given off in distinct aggregations from a special stroma. This characteristic separates it definitely from *Clasterosporium*, which is among the Hyphomycetes. Otherwise, so far as can be observed from descriptions and plates, the *Clasterosporium* of McAlpine is identical with our *Coryneum*.

So far as mycological characters show, there is only one species of *Coryneum* on the various stone fruits in California. We are not yet ready to report upon the matter, however, from the standpoint of cross-inoculation, as experiments are still in progress.

The mycelium producing the spots on peach leaves and shoots during the winter, fruits by means of spore pustules which occur as minute black specks (four or five) near the center of the more or less circular spot. The tissue of the leaves so affected soon drops out, so that it is often difficult to find the conidia at this season of the year, especially where only the young, spotted shoots are at hand. The spots on the bark are more often sterile, which is sometimes true of the leaf spots as well. By the end of the infection period, however, the spores have become quite abundantly scattered about on the twigs. The fertile spots, on sectioning, show distinct pustules with well-developed stromata, which push out until the epidermis is ruptured, after which the short conidiophores with their olive-colored elliptical spores appear as dense clusters on the surface. (Fig. 13.)

Especially on twigs from which the affected leaves have fallen the conidia are found in abundance about the leaf scars and roughened portions of the bark during the spring and summer. (Fig. 14, *c*.) If a late rain occurs they germinate, causing new infection on the remaining leaves, and are ready with the fall rains to infect and kill outright many of the newly formed buds.

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[1] Mich. Agr. Exp. Sta. Bull. 103, p. 57. 1894.
[2] Ohio Agr. Exp. Sta. Bull. 92, p. 225. 1898 and other State Bulletins.
[3] Fungus Diseases of the Stone Fruits in Australia and their treatment, by D. McAlpine. March, 1902.
[4] Le Coryneum, Maladie des Arbres a Noyaux, in Bulletin Agricole de l'Algerie et de la Tunisie. No. 10, May, 1904. By Dr. Trabut.

Though many of the conidia thus distributed are those which fall from the spots on leaves and green bark, it was found that these conidia

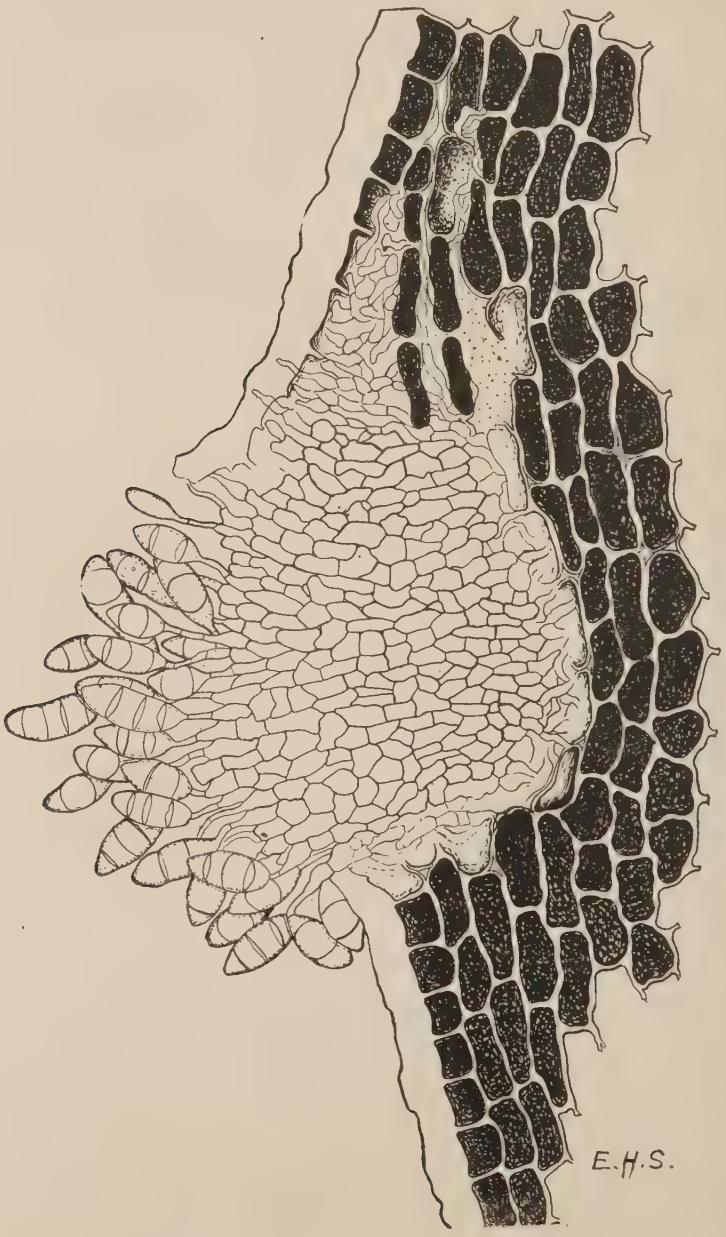

FIG. 13. Longitudinal section through a *Coryneum* pustule on peach spot.

reproduced themselves more or less with moisture on the dead outer cells of the older twigs. This occurs often as a mold-like growth on the surface of the bark, much as in artificial media. Characteristic pustules are found on the leaf scars, however, sometimes in considerable abundance.

The life history of the *Coryneum*, then, as shown by our experience, is as follows: The spores, scattered profusely over the limbs, germinate as soon as enough rain has fallen to wet them up thoroughly, usually in December or January. Spores lying on the green bark of new shoots penetrate the tissue and cause the characteristic spotting, the mycelium from each germinated spore killing a small area of the bark. Spores lying about the bud scales produce a mycelium which penetrates and kills outright both the bud and quite an area of surrounding bark, the spot extending from one-fourth to one inch in length. On the spots spore pustules are developed, the conidiophores being produced on a stroma under the epidermis which is ruptured by the spores. (Fig. 13.)

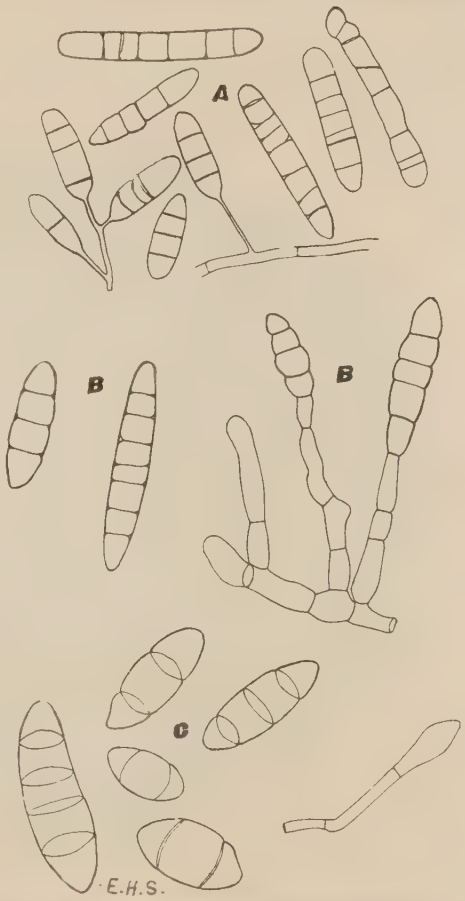

FIG. 14. *Coryneum* spores: *a*, from petri dish colonies in agar; *b*, from prune agar tube cultures; *c*, from pustules on peach bark. (All drawn to same scale.)

When the buds which have survived the winter attack unfold in the spring, the leaves are very generally affected by the fungus, causing small dead areas in the leaf tissue, which soon dry up and fall out, causing the so-called "shothole" effect of the leaf. Pustules are also found on the leaf spots. In the majority of seasons the new infection ceases at the end of April. In seasons where a late rain occurs in spring, however, the spores produced on

the winter infection germinate instead of remaining dormant till fall or winter, and not only leaves, but the new shoots and even the young fruit become spotted at this time. The mycelium in the newly affected tissue produces spores in turn, thus furnishing a fresh supply for the winter attack.

The alarming phase of the fungus, economically, is this winter killing of the buds, together with the area of the bark about the bud which is involved in the destruction. As new growth proceeds the tension

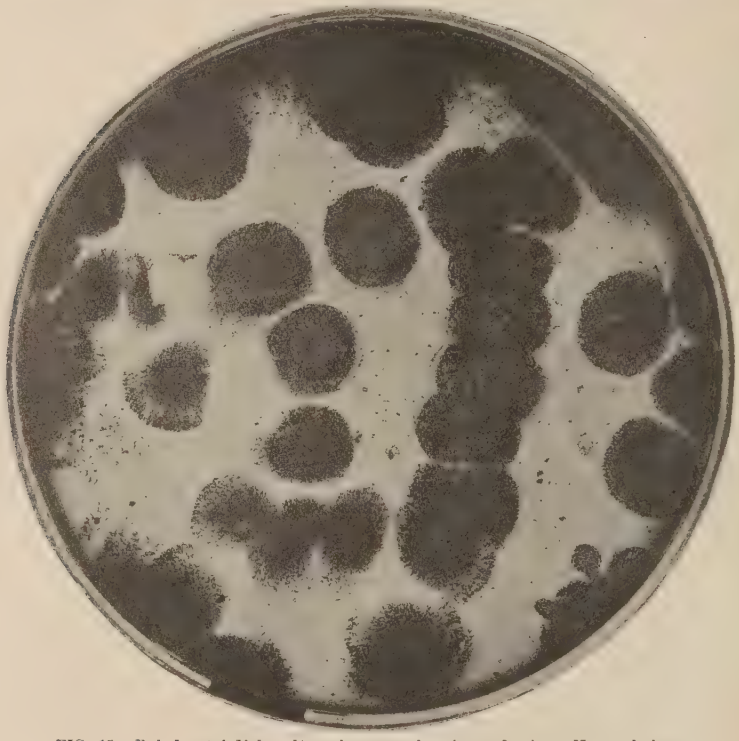

FIG. 15. Dried petri dish culture in agar, showing colonies. Natural size.

which is set up between the dead and the growing bark surrounding it causes a fissure, from which the gum is exuded. This gumming from lesions around the dead buds is chiefly confined to the new wood, since, where the tree has sustained the attack sufficiently, old wounds are more or less healed over at the time of the next year's flow. This attempt at healing on the part of the tree causes the cankers so often found on the limbs of affected trees. Where the vitality of the tree is low, however, from the loss of buds, leaves, and sap for perhaps several consecutive years, there are sometimes "gumming" wounds left in the older wood.

As yet we have failed to procure abundant growth in culture from spores taken from the bark or leaf. This is to be accounted for, at least in part, by the fact that the copious gum exuded from the cankers of the diseased bark produces an abundance of mold spores of various kinds besides bacteria and yeasts, which outgrow the *Coryneum* in initial cultures. Moreover, during the winter and spring the surface of the tree is often moist and sticky throughout from escaping sap, in which many of the spores have already germinated. The fact remains, however, that mature spores under seemingly favorable conditions in whatever season usually fail to grow in culture when taken from the tree. Often only one colony is secured out of a dozen or more petri dish cultures in peach or ordinary agar. Once secured in culture, however, it can be reproduced readily in either of the above named media. It also grows luxuriantly on sterilized peach twigs in tubes.

FIG. 16. Microphotograph of *Coryneum* pustule on sterilized peach twig.

The colonies in agar petri dish culture are black, with distinct zones of conidia, the colonies being submerged in the medium. (Fig. 15.) On prune or acid agar slants the fungus produces a black surface crust composed almost entirely of spores. The mycelium, sparingly produced in culture, is colorless. On sterile twigs distinct pustules are formed, as in Fig. 16, which appear to the naked eye as black specks on the epidermis. The size of the pustule is more or less uniform, both in natural infection and in twig cultures, measurements varying from 100 μ to 166 μ with pustules observed. Shape is somewhat cubical or rounded. The spores as occurring naturally do not vary materially in length from those in agar plates, the minimum length being 17 μ, maximum 44 μ, average 30–40 μ. Width in "natural" spores, however, is uniformly about 13 μ, and number of cells 3 or 4, rarely 5, while in

agar colonies width is about 6 μ, and number of cells from 3–12, usually 6 or 7. On sterile twigs the spores do not average more than 20 μ in length, and range from 3 to 6 cells, usually 4. (See Fig. 16.)

The peach trouble identified as being caused by *Helminthosporium carpophilum* (Lev.) in this country (see cit. 1, 2, 3) is stated by McAlpine to be identical with his *Clasterosporium*. In our work we have found the spores of agar cultures particularly suggestive of this type, being narrow, of uniform width, and often nearly oblong in shape. In short, there appear to be two types of spores belonging to the peach *Coryneum*, one borne on a distinct stroma in pustules, elliptical and confined to three or four cells, the others of hyphomycetous origin, more or less oblong, and from 3 to 12 cells. (Fig. 14.)

Vuillemin in 1890 described a new species of *Ascospora* (*A. beyerinkii* Vuill.) which he considered to be the perfect form of *Coryneum beyerinkii*. Up to the present time we have found no indication of an ascomycetous stage of any kind. The conidia appear to live over the dry, summer season, lodged in the bud scales and bark, as previously described. That it is possible for the spores to live several months in a dry condition has been proved by laboratory experiments.

Of the various molds encountered in a study of the diseased tissue, sooty mold and a species of *Phyllosticta* have been found most constantly in connection with it. The former spreads itself over the surface of the dead spots, often rather soon after infection, forming a single layer of connected cells, which give off bud conidia in the manner characteristic of this class of fungi. The *Phyllosticta* is found more often on spots which are thoroughly dead and dry, the whole surface being dotted with the small pycnidia, which give off minute, unicellular conidia from short conidiophores. The writer has found no fungus associated with the *Coryneum* which could readily be confused with it as the cause of peach blight.

RECOMMENDATIONS FOR PEACH BLIGHT AND CURL LEAF CONTROL.

Spray thoroughly with Bordeaux mixture between November 1st and December 15th. The work may begin as early as October 25th.

Use 30 pounds of bluestone and 35 pounds of quicklime to 200 gallons of water. If materials are very high, somewhat less may be used, down to 20-20-200.

Prune if possible before spraying, but do not delay the work on account of pruning.

About February 15th, or just before the buds open, spray again with Bordeaux, 20-20-200, or lime, salt and sulfur.

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